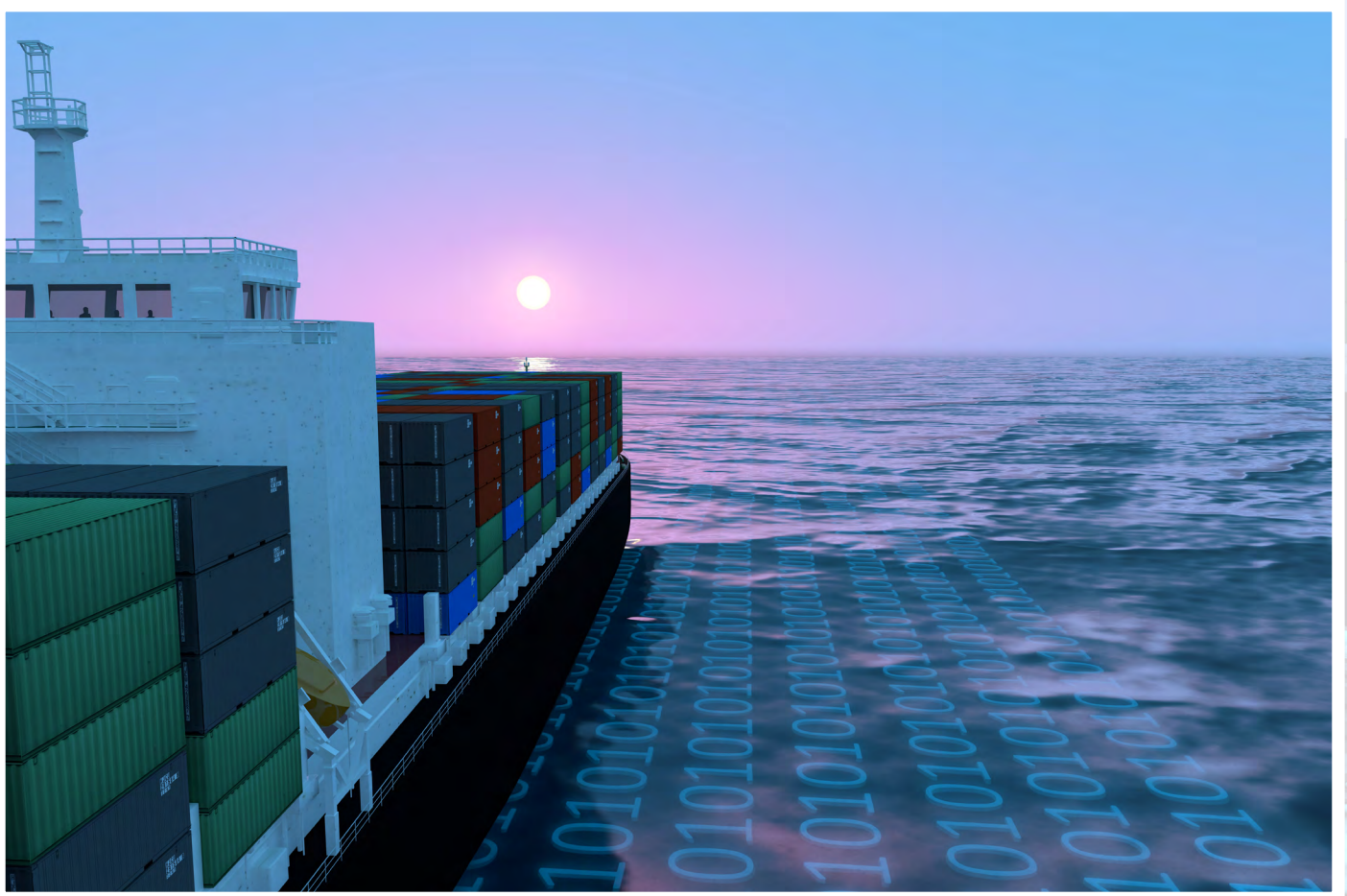


REMOTE CONTROLLED AND AUTONOMOUS SHIPPING: UK BASED CASE STUDY



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EXECUTIVE SUMMARY

Various companies and organisations have been working for some time to develop Maritime Autonomous Surface Ships (MASSs) that can be used in commercial shipping. As it is often the case with emerging technologies, there is a risk that such technological developments might well be ahead of the current legal and regulatory framework and that adjustments in the regulatory sense will need to be made within a short period of time. The primary objective of this study is to highlight the regulatory and legal challenges that need to be addressed so that MASSs can operate within UK territorial waters without complication. Thus, for the purposes of this study three assumptions have been made: i) the hypothetical vessel in question will navigate from Hull to Plymouth staying entirely within UK territorial waters; ii) this vessel is registered in the UK and iii) this craft will have a varying degree of autonomy, i.e. it will be mainly controlled remotely (from Swansea) but will have autonomous navigation/operation-capability which will be activated in some cases.

The Report concludes that it will be within the remit of different regulatory bodies to deal with the legal and regulatory challenges ahead. For example, the Marine and Coastguard Agency (MCA) is expected to provide regulatory solutions to issues concerning safety and technological requirements of MASSs. Port and harbour authorities need to specify the conditions that a MASS should comply with to gain access into areas that come under their jurisdiction. There is also a requirement to deal with issues concerning pilotage by competent harbour authorities. We also conclude that legislative changes are needed to clarify matters concerning liability (collision liability and product liability), limitation of liability, salvage, cargo claims and arrest of MASSs as well as to deal with criminal law issues that might emerge.

I. SCOPE OF THE STUDY

1. Autonomous shipping at its widest is an incredibly broad subject. Indeed, these days ships are at least to some extent operating independent of human intervention. The International Convention for the Safety of Life at Sea (SOLAS) 1974, for example, requires any vessel of 10,000 GRT upwards to have at the very least an automatic heading or track control system whose function is automatically to control and keep the vessel to a heading and/or straight track.¹

2. This study concentrates on a more limited and potentially disruptive area of automation, which is becoming increasingly topical: namely the introduction of Maritime Autonomous Surface Ships (colloquially known as MASSs). The IMO, in the course of a recent regulatory scoping study of potential changes to regulatory requirements arising from this,² divided MASSs into four categories (referred to as “degrees”):

Degree One: *Ship with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.*

Degree Two: *Remotely controlled ship with seafarers on board: The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.*

Degree Three: *Remotely controlled ship without seafarers on board: The ship is controlled and operated from another location. There are no seafarers on board.*

Degree Four: *Fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.*

3. This categorisation is admittedly open to criticism for being over-simplistic in the light of recent developments in technology. But it is a good starting point, and given its adoption by the IMO’s Maritime Safety Committee for its future regulatory work,³ we will work from it.

4. As we understand it, the four degrees of autonomy referred to above can be most easily understood by reference to the division of responsibilities for operation and control between humans and computer systems, as appears in the Table below:

¹ Chap.V.2.8.

² Published on June 3 2021 and available here: [MSC.1-Circ.1638 - Outcome Of The Regulatory Scoping Exercise For The Use Of Maritime Autonomous Surface Ships... \(Secretariat\).pdf \(imo.org\)](#) (last tested on 1 November 2021).

³ At its 103rd session (5 to 14 May 2021).

Table 1

	Operation	Monitoring	System Assurance
Degree One	Human	Human	Human
Degree Two	System	System	Human
Degree Three	System	Human/System	Human/System
Degree Four	System	System	System

Note: there is, in principle, no operational crew on board at Degree three and upwards. It will be assumed that monitoring is going to be undertaken by the system and also by a remote watch officer. The remote operator in certain circumstances will be required to take control of the ship's operations. If no action is taken by the operator (e.g. due to a communication failure), the system will have to act autonomously and carry on with the operation of the vessel.

5. This is specifically a legal study. Admittedly shipping is a multijurisdictional business, and in practice most problems in shipping law potentially involve reference to multiple systems of municipal law. But simplification is sometimes necessary; and this study will assume that only the law of England and Wales is in play.⁴ To avoid foreign law complications, we will therefore base our comments on a domestic scenario; namely, a voyage by a coasting container vessel, the *MV Albion*, British owned and UK registered, from Hull to Plymouth. The vessel is, we will assume, directed from a control centre in Swansea, but is technically capable of Degree Four autonomy, which is programmed automatically to kick in should contact with the control centre be lost for any reason. The contract between *Albion's* owners and the control centre expressly applies English law and submits all claims to the jurisdiction of the High Court in London. Her voyage plan lies entirely within UK territorial waters: that is, keeping at all times within 12 miles of the British coast and keeping to the British side in the Straits of Dover TSZ.

6. In the next section we consider the regulatory and legal challenges that need to be addressed to ensure that MASSs can operate without complications within UK territorial waters. In particular, we shall refer to technical matters that need to be addressed by regulators⁵ so that a voyage of the kind described above can be safely carried out. We shall also aim to highlight the possibility of necessary changes to primary legislation, given that applying current legal principles to MASSs may on occasion create unexpected or undesirable outcomes.

⁴We deliberately refer to English and Welsh law rather than UK law. While Northern Irish shipping law can be taken to be the same as English, Scottish shipping law is not (though it is in many ways similar). We disregard it here, not with intent to show any disrespect to the Scots, but merely to preserve simplicity. In practice, many of our comments are likely to be equally applicable on both sides of the Tweed.

⁵The main relevant regulatory body here is expected to be the Maritime and Coastguard Agency (MCA). For small vessels, the MCA, utilising the power delegated by the Merchant Shipping (Small Workboats and Pilot Boards) Regulations 1998, has put in place a Code of Practice setting the standards that such vessels ought to comply with concerning safety and operational matters. Recently, the MCA published the Workboat Code V2 which updates the safety and navigational requirements for such vessels. The Workboat Code V2 applies compulsorily to all vessels which are less than 24m in length. For MASSs which are less than 24m in length, obviously the Code needs to be reviewed but also for larger vessels operating in territorial waters of the UK one would expect the MCA to be tasked to put in place a regulatory framework designed to provide equivalent standards for construction, operation, maintenance, emergency response, health and safety, environmental risk management especially in the absence of any international regulation in this field. That said, the involvement of other regulatory bodies will be essential, notably port authorities (which also deal with pilotage). In so far as primary legislation may be necessary, this is obviously a matter for Parliament.

II. OPERATIONAL AND NAVIGATIONAL MATTERS

(A) Remote Control Centres (RCCs)⁶

7. It is obvious that RCCs will play a crucial role in the operations of the MASSs by way of remote command, control and/or monitoring. Obviously, the current maritime conventions and national regulations are silent on the functional and operational requirements of such centres. This is something that need to be addressed as a matter of urgency, ideally in consultation with those developing such technology.⁷

8. In similar vein, there is a legal vacuum when it comes to the requirements the conventions and national regulations lay down for the qualifications and training needs of personnel in such centres.⁸ This vacuum needs dealing with in detail. One would expect such personnel to have a good understanding of navigational matters, as with seafarers; but given that they are not expected to go on board, some matters relevant to traditional seafarers' qualifications may be able to be omitted. Conversely, however, some further qualifications may well be necessary: notably, a good technical knowledge of the relevant computer and communication systems how to deal with an emergency within the RCC and how to respond to an emergency condition on board the vessel or in respect of an maritime search and rescue (SAR) request.

9. There are also two particular matters of specific importance concerning RCC personnel. First, it is vital to define the technical legal status of the person in an RCC who assumes command of a MASS. It would make sense to view them equivalent to a conventional master,⁹ especially given that the relevant international regime requires flag states to ensure that each ship under their flag is in charge of a master.¹⁰ However, this in turn creates a need to look again at a number of international conventions that clearly assume (and arguably by implication require) the presence of a master on board. For example, under the STCW 1978¹¹ it is stated that officers in charge of the navigational watch should be physically present on the navigating bridge or in directly associated locations, such as a chartroom or bridge control room at all times. It is very doubtful whether an RCC would be considered as being a navigational bridge.

10. Secondly, and perhaps more fundamentally, it is essential to specify the relationship between the different persons in an RCC responsible for a MASS. Discussions with the builders of such vessels have revealed that the chain of command in respect of such vessels may be different from conventional ships, as appears in Diagram 1 below.

⁶ These are also referred to as "Remote Operation Centres (ROCs)" in some reports.

⁷ Preliminary guidelines on these matters have been provided in a voluntary code put together by the UK Maritime Autonomous Systems Regulatory Working Group (MASRWG) published by Maritime UK – available at <https://www.maritimeuk.org/priorities/innovation/maritime-uk-autonomous-systems-regulatory-working-group/mass-uk-industry-conduct-principles-and-code-practice/> (last tested 1 November 2021). For example, an RCC is defined in this document as "the set or system of equipment and control units that are needed at the site or sites where safe and effective remote command, control and/or monitoring of the MASS, or several MASS, is conducted". Chapter 11 defines architecture and potential responsibilities of RCC and provide outline requirements for their functions.

⁸ One should not lose sight of the fact that there is also a need to consider the working conditions and rights of those working at such centres. They are entitled to the protection that every employee working in the UK enjoys. Their working conditions are rather different than those working on board of a ship and naturally regulations that are designed for seafarers would not be appropriate in this context.

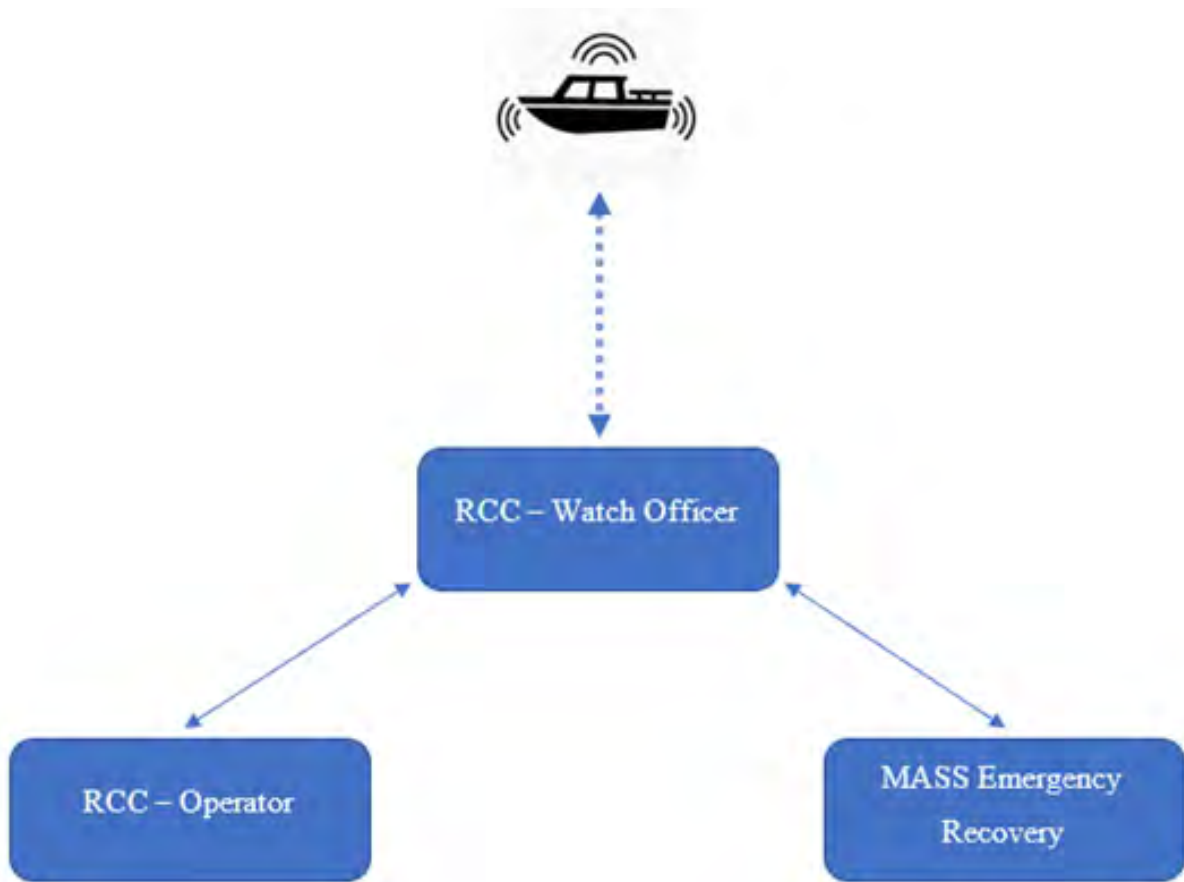
⁹ Compare s.313 of the Merchant Shipping Act 1995, defining a master as a "person (except a pilot) having command of a ship". This would seem to cover a remote controller with full command of a MASS.

¹⁰ See the United Nations Convention on the Law of the Sea (UNCLOS) 1982, Art.94(4)(b).

¹¹ See Reg.VIII/2 part 4-1, paras. 18, 24 and 32.

Diagram 1

Basic RCC Operations



11. In a case when the connection between the MASS and the RCC is lost (e.g. because of an accident, a technical problem or for that matter a deliberate cyber-attack), the system ought to be able to take immediate control of the MASS since those working in the RCC, while they will be expected to re-establish communication or control as soon as possible, may not be able to do so for some time. However, at this point other problems arise. What happens in cases where the RCC system itself fails or malfunctions and accordingly the operator fails to maintain command of the vessel? What if there is an excessive delay in activation of the autonomous functions?

12. These will have a significant bearing on the potential liability of the operator; but more significantly it is essential for regulators to specify technical requirements expected of an RCC to prevent such things happening as far as possible. In other words, apart from qualifications and training for RCC personnel, regulation needs to specify (i) how the co-ordination between different units will be achieved; (ii) the role and function of each operator within the RCC; (iii) what technical requirements and designs an RCC should have to ensure safe operations; and (iv) the safety management system that needs to be put in place. We believe that such regulatory specification will play a key role when it comes to attributing liability to various parties, especially operators, for their default or negligence.¹²



¹² It is encouraging to see that DNV, a well-known classification society, has recently introduced the industry's first competence standard for vessel remote control centre operators named as DNV SeaSkill Standard ST-0324. The standard is supported by a new recommended practice that offers a certification scheme for operators. Together, they provide a framework for training, assessing, and certifying personnel working in remote-control centres that support or manage operations at sea. This is an encouraging development of course but it does not deter from the fact that there is an urgent need to provide regulatory guidance in this area.

B) Ports

13. The use of ports in the United Kingdom is subject to a combination of national and local regimes. Most ports are governed by the general provisions of the Harbours, Docks and Piers Clauses Act 1847 and the Harbours Act 1964 (or in the case of ports such as Plymouth attached to naval installations, the Dockyard Ports Regulation Act 1865). In addition, most ports are also subject to local rules made under various subordinate legislative powers.¹³

14. Current English port law was not drafted with MASSs in mind. Nevertheless, there is, it seems, no *general* rule of port law that can be construed as requiring vessels to be controlled by a crew on board, or indeed to have a crew at all. MASSs therefore on principle have as much right to use English ports as any other vessels. On the other hand, since ports have the right to regulate their mode of use,¹⁴ subject to the principles of non-discrimination,¹⁵ it does not seem that there is any general legislative requirement that they accept MASSs. If a port so wished, it could therefore exclude MASSs entirely by insisting that vessels using it be crewed.

15. As we pointed out above, current English port law was drafted without reference to MASSs. As we see it, assuming a port authority has no wish to exclude MASSs altogether, two matters call for urgent regulatory action.

(i) The reconsideration of specific rules which, although not designed to do so, incidentally make the use of a port by MASSs impossible. For example, within the limits of Humber port a power-driven vessel of any size while underway is required to have a competent person on the bridge,¹⁶ not to navigate without at least two people on board,¹⁷ and to keep at least one person on board when moored¹⁸ or anchored.¹⁹ Again, in the Port of Plymouth it is illegal to anchor in or near any of certain navigable channels without someone being on board,²⁰ to navigate anywhere in the harbour without maintaining a VHF listening watch in the wheelhouse,²¹ or without maintaining a competent helmsman in a steering position when a vessel is under the control of an automatic pilot.²² In addition all vessels are required to render assistance on request to lifeboats, coastguard and other official vessels, which may be difficult if a vessel is unmanned. It is our view that steps will have to be taken to disapply the above provisions in the case of MASSs which meet particular safety standards to be specified.

¹³ There is, for example, a general power to make bye-laws under s.83 of the 1847 Act just mentioned, and also under ss.3, 5, 6 and 7 of the 1865 Act. The Humber Navigation Byelaws 1990 applying to the Port of Hull are made under the former powers, together with a number of more particular pieces of legislation. The rules relating to Plymouth fall in the latter category: see the Dockyard Port of Plymouth Order 1999 (SI 1999/2029).

¹⁴ Notably because of the power to issue bye-laws under s.83 of the Harbours, Docks and Piers Clauses Act 1847, and harbour directions under ss.40A-40D of the Harbours Act 1964.

¹⁵ Provided for by s.33 of the Harbours, Docks and Piers Clauses Act 1847 ("Upon payment of the rates made payable by this and the special Act, and subject to the other provisions thereof, the harbour, dock, and pier shall be open to all persons for the shipping and unshipping of goods, and the embarking and landing of passengers").

¹⁶ Humber Navigation Byelaws 1990, Byelaw 8.

¹⁷ Humber Navigation Byelaws 1990, Byelaw 11(1).

¹⁸ Humber Navigation Byelaws 1990, Byelaw 27.

¹⁹ Humber Navigation Byelaws 1990, Byelaw 31.

²⁰ Dockyard Port of Plymouth Order 1999 (SI 1999/2029), Sch.1, Art.3.

²¹ Dockyard Port of Plymouth Order 1999 (SI 1999/2029), Sch.1, Art.36.

²² Dockyard Port of Plymouth Order 1999 (SI 1999/2029), Sch.1, Art.39.

(ii) References to a vessel's "master". As with the STWC mentioned in Para. 9 above, legislation relating to ports frequently refers to the duties of the "master" of a vessel. This is defined in s. 3 of the 1847 Act and other legislation²³ as the "person having the command or charge of the vessel for the time being". Unfortunately, such a definition may be difficult to apply to a vessel under control from an RCC, and well-nigh impossible where a vessel is sailing entirely autonomously. We suggest two specific changes:

(a) The owners or operators of a MASS should be required by law to nominate a person to fulfil the statutory role of "master", to whom notices required to be sent to the "master" can be communicated;

(b) It should be provided in law that, in the case of a MASS, any legal penalty or liability attaching to the "master" should attach to the above person, and should also attach to the registered owner of the vessel. This could be done by a general legislative provision stating that wherever effective control of a vessel was being exercised by a person not on board, then any legal penalty or liability arising under any enactment should, unless the context required otherwise, attach to that person.

²³ See s.2 of the 1865 Act and s.57 of the Harbours Act 1964, and numerous local orders and bye-laws.

(C) Pilotage

16. There is little international regulation on issues concerning pilotage,²⁴ so regulating such matters is entirely within the purview of any national state concerned. As far as the UK is concerned, the Pilotage Act 1987 creates “competent harbour authorities” which have the power in relation to the regulation of shipping movements and the safety of navigation within harbours and other areas that come under their jurisdiction.²⁵ There are over ninety competent harbour authorities in the UK.²⁶ Under the Pilotage Act 1987, the authority has power to determine whether pilotage should be compulsory in their respective areas of competence,²⁷ to set the requirements for licensing of pilots²⁸ and to grant pilotage exemption certificates.²⁹

17. Obviously, the rules as they currently apply do not make any provision for remotely controlled or autonomous vessels. It is our view that the following issues need to be considered and regulated as a matter of priority:

(i) There is an urgent need to specify the nature of the pilotage services to be offered to such vessels. It would make little sense for a pilot to come on board of a vessel operated through an RCC or navigating autonomously, unless there was a pressing need. For such vessels, one would expect pilotage services to be offered remotely. In fact, Finland has just passed a legislation enabling remote controlled pilotage.³⁰ There is no obstacle in the UK legislation for the introduction of a similar pilotage service. A “pilot” in UK legislation is described as “any person not belonging to a ship who has the conduct thereof”.³¹ Therefore, it is not a legal requirement that the pilot should be on board the vessel they are assisting.

(ii) Assuming that remote pilotage is the way forward for MASSs, the following issues should also be addressed:

(a) Competent harbour authorities (in our example in Hull and Plymouth) need to put in place rules concerning training and operational procedures for remote pilots. It would certainly help if such requirements were consistent nationally, so perhaps a national body, such as the MCA, should assume the role of determining such regulatory standards.

²⁴ Save for two exceptions. First, the Recommendations published by the IMO in 2003 on the training of, and operational procedures for, maritime pilots other than deep sea pilots: IMO Resolution A. 960(23) of 5 December 2003. Second, in the case of collisions, the Brussels Convention 1910 requires that the owner of a vessel be responsible for the actions of a compulsory pilot.

²⁵ See s. 1(1) of the Pilotage Act 1987.

²⁶ For example, Associated British Ports (ABP), which owns many of the UK’s larger ports, is the competent harbour authority both for Hull and Plymouth ports

²⁷ See s. 7 of the Pilotage Act 1987. For example, Pilotage Directions 2019 South Wales, published by ABP South Wales, stipulate that pilotage is compulsory in the following instances:

i) All vessels or tows of over 85.00 m length overall;

ii) All vessels or tows of over 20.00 m length overall carrying: a) Dangerous or noxious liquid substances in bulk b) Twelve or more passengers. c) Explosives.

iii) All vessels that are engaging the assistance of “Harbour tugs”

iv) All vessels or tows of more than 60 m but less than 85 m unless a bona fide deck officer has navigated the port on that vessel or a vessel of a similar class in the past 12 months.

²⁸ See s. 3 of the Pilotage Act 1987.

²⁹ See s. 8 of the Pilotage Act 1987.

³⁰ Law 51/2021, amending the Pilotage Law 2003.

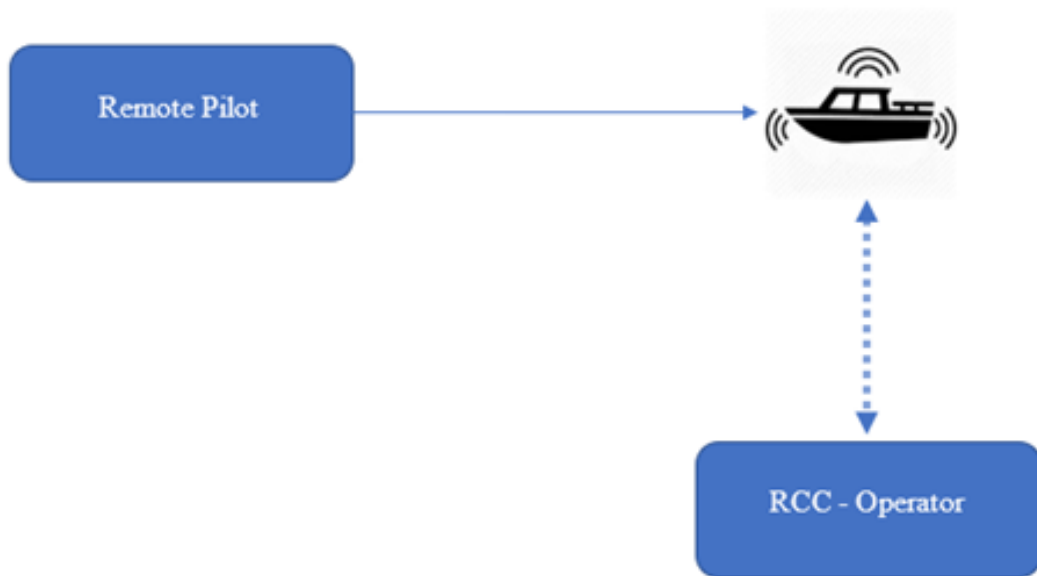
³¹ Section 31(1) of the Pilotage Act 1987.

(b) Computer systems running a ship must be able to switch over, to allow input from a remote pilot. This is a technical issue but illustrates the need for regulators to work closely with manufacturers of MASSs.

(c) As discussed earlier, it is imperative to determine the legal status of the remote control operator and it would make sense to attribute this person a status akin to the status of a master. Even so, a critical question remains: what if a vessel is under remote pilotage and the controller feels (for example because the pilot is patently incompetent or drunk) that they need to intervene to retake control? We are of the view that MASS systems should be required to be developed in a way that the remote operator retains ultimate control in such a case.³²

³² This would not noticeably affect questions of legal liability. A ship operator is always liable for the negligence of a pilot in any case, whether pilotage is compulsory or not. The pilot is theoretically liable to third parties for any negligence they commit, but liability is limited under s.22 of the Pilotage Act 19787 to the comparatively insignificant sum of £1,000.

Diagram 2



Who has ultimate control of the MASS?

(iii) Another issue regarding pilotage that needs to be addressed is whether MASSs could be exempted from compulsory pilotage. It is, for example, in the discretion of the competent harbour authority to request such vessels to operate at Degree 4 (in full autonomy) at certain areas. In that scenario, there is a case to argue that a blanket exemption should be issued for MASSs especially given that in that mode of operation manual override of the autonomous systems of a MASS will not be viable. Although this is a possibility, we are of the view that apart from public concern over safety, such a move, which will have the effect of reducing the significance of the pilotage sector, will be resisted.

(iv) Lastly, there is a need to determine whether remote control operators can be issued pilotage exemption certificates. Section 8(1) of the Pilotage Act affords a discretion to the competent harbour authority to issue, on application, to any deck officer³³ if specific requirements are satisfied.³⁴ On that basis, assuming that the legal position of a remote operator is treated to be akin to a ship master, there is nothing in the current legislation preventing such operator from making an application to a competent harbour authority to be issued an exemption certificate from pilotage. However, we believe this is also a matter that needs to be addressed explicitly in any relevant regulation.



³³ Deck officer, in relation to a ship, includes the master and first mate according to s.31(1) of the Pilotage Act 1987.

³⁴ If the skill, experience and local knowledge of the relevant person is sufficient for them to be capable of piloting the ship of which (s)he is a deck officer (or that and any other ships specified in the certificate) within its harbour or such part of its harbour as may be so specified; and in any case where it appears to the authority to be necessary in the interests of safety, that his/her knowledge of English is sufficient for that purpose.

D) Salvage

18. Under the maritime law of salvage, a person who successfully saves a vessel from imminent danger in navigable or other waters is entitled to an award of such sum as is fair and just in the circumstances, taking into account such matters as the degree of skill involved, the value of the property salvaged, the degree of danger and a large number of other factors.³⁵ The principle of salvage is universally (though not identically) applicable in all significant maritime jurisdictions.

19. In England and Wales salvage is governed by the provisions of the Salvage Convention of 1989, incorporated into domestic law by the Merchant Shipping Act 1995.³⁶ Salvage services need not strictly speaking be rendered under a contract, so that (for example) if a vessel finds another ship abandoned and the crew immediately proceed to save her, a salvage liability will still arise. In practice, however, nearly all salvage today is carried out under contract, with the contract being contained in a standard document, such as Lloyd's Open Form or the US Open Form Salvage Agreement.

20. The Salvage Convention 1989 predates the introduction of MASSs. In fact a good deal of it carries across quite neatly to autonomous vessels such as the one in our example transiting between Hull and Plymouth. For example, this is certainly true as regards subject-matter. Under the 1989 Convention salvage applies to any "vessel" or "property", a "vessel" being defined as "any ship or craft, or any structure capable of navigation".³⁷ There can be no serious doubt that this includes a MASS. Again, if an abandoned vessel is found and brought safely to port, it fairly clearly makes no difference to the nature of the services, or the remedy available to the person providing them, whether was originally crewed or uncrewed.

21. Nevertheless, there are two points of importance where we consider regulatory updating to be necessary.

(i) The position of the "master" of a vessel. The "master" of a vessel plays an important part in the scheme of the 1989 Salvage Convention. S(he) features in at least five instances:

(a) Under Art.6.2, "The master shall have the authority to conclude contracts for salvage operations on behalf of the owner of the vessel. The master or the owner of the vessel shall have the authority to conclude such contracts on behalf of the owner of the property on board the vessel."

(b) Under Art.8.2, "The owner and master of the vessel or the owner of other property in danger shall owe a duty to the salvor (a) to co-operate fully with him during the course of the salvage operations; (b) in so doing, to exercise due care to prevent or minimize damage to the environment; and (c) when the vessel or other property has been brought to a place of safety, to accept redelivery when reasonably requested by the salvor to do so."

³⁵ The subject is helpfully summarised in the leading legal text, Kennedy and Rose on the Law of Salvage (10th ed) (Sweet & Maxwell, 2021), Ch. 1.

³⁶ See Part 9, Chapter 1, and Schedule 11, Part 1.

³⁷ Art.1(b).

(c) Under Art.10.1, "Every master is bound, so far as he can do so without serious danger to his vessel and persons thereon, to render assistance to any person in danger of being lost at sea."

(d) Under Art.15, "The apportionment between the owner, master and other persons in the service of each salving vessel shall be determined by the law of the flag of that vessel."

(e) Under Art.19, "Services rendered notwithstanding the express and reasonable prohibition of the owner or master of the vessel or the owner of any other property in danger which is not and has not been on board the vessel shall not give rise to payment under this Convention "

Apart from Art.15, which is inapplicable in the nature of things to a MASS, these provisions can be difficult to apply where a vessel is uncrewed, since in such a case there is no-one who readily answers the description of "master". To accommodate this problem, there needs in our view to be an amendment to the Merchant Shipping Act 1995. This should state that, for the purposes of the Salvage Convention, where a ship is uncrewed or under RCC control the term "master" shall include the person from time to time in control of the vessel at a relevant control station.

(ii) The place where salvage services are rendered. The 1989 Salvage Convention defines salvage services as "any act or activity undertaken to assist a vessel or any other property in danger in navigable waters or in any other waters whatsoever."³⁸ With autonomous vessels, the saving of the vessel from danger might well entail entirely land-based operations. Examples might include the hiring of IT consultants to sort out an onboard computer failure, or to rescue a vessel under computer control from the clutches of cyber-hackers intent on taking her over. Such operations deserve to be treated as salvage. We take the view that the Merchant Shipping Act 1995 should be amended to ensure that they are, despite the fact that they may be entirely land-based.

³⁸ Art.1(a).

(E) Liability Relating to Navigation: Collision etc

22. This section sets out the law of England and Wales on the potential liabilities of ship operators and remote controllers for damage to other vessels, fixed or shore installations arising out of collisions.

23. The present law is complex but can be summarised as follows.

(i) In general.

Subject to two exceptions referred to below, legal liability for damage or injury caused by maritime collisions depends on proof of fault. Where a collision occurs entirely without fault on anyone's part (which is admittedly rare in practice), then losses lie where they fall and there is no liability.

The fault may be that of those on board a vessel, such as a master, engineer or officer of the watch; in so far as such persons are negligent, their employers (in practice the vessel's owners, or in the case of a vessel bareboat chartered, the charterers) will be liable. Very relevant in this connection are the International Regulations for Preventing Collisions at Sea, colloquially known as Colregs, which lay down rules and standards to be observed by vessels with a view to avoiding and mitigating the risk of collision.³⁸

But the negligence need not necessarily be that of those on board. If it can be shown that a collision resulted from some shore-based fault of her owners or bareboat charterers, then the latter may equally be liable. Examples would be where a casualty was shown to have resulted from inadequate training of the crew in how to handle emergencies, or inadequate maintenance of steering gear leading to its failure at a crucial moment. In practice, a high standard is expected both from those on board a vessel and from those concerned with her maintenance and the training of the crew, and even small faults are likely to lead to liability.

Where the owners or operators of a vessel are liable in respect of a collision, in practice any damages are paid by the vessel's hull or P&I insurers. In the rare cases where this does not happen, or there is no valid insurance policy in force, it is open to the owner of any property damaged, or any claimant injured (or his relatives in the case of death) to arrest the vessel in order to secure their claim.

(ii) Cases of liability without fault.

There are two important exceptions to fault liability. Where a vessel is in collision with fixed harbour installations in England and Wales, legislation (in the shape of a nineteenth-century statute, the Harbours, Docks and Piers Clauses Act 1847, s.74) makes the owners automatically liable for the damage even if they are completely without fault.

³⁸Their detailed effect is summarised in Marsden & Gault, *Collisions at Sea* (15th ed) (Sweet and Maxwell, 2021), Chapter 7.

But note: this liability attaches only to the registered owners of the vessel, and applies only to harbour installations, not e.g. other fixed objects such as exploration platforms where fault must be shown in the ordinary way.⁴⁰ The other exception is strict products liability. Where a collision is due to the failure of new equipment placed on board a vessel, such as navigational or radar equipment, or steering or engine control mechanisms, the producer of the equipment may find itself strictly liable under product liability law, namely Part I of the Consumer Protection Act 1987, for any death or personal injury resulting. This subject is dealt with in greater detail below.⁴¹

24. The above rules were developed in the nineteenth century without reference to MASSs, but would apply equally to the autonomous vessel sailing from Hull to Plymouth in our example, whether she is sailing entirely under her own on-board automatic controls or under the supervision of an RCC. Thus, subject to the two exceptions mentioned above, liability continues to depend on fault. Of course, if there is no-one on board there can, in the nature of things, be no question of crew negligence. But it may well still be possible to prove negligence in her owners and operators for failing properly to supervise her operation or maintain her to an adequate standard. Note, however, that vessel owners or operators will be liable only for their own negligence, and will not normally bear responsibility for the fault of an RCC.

25. In addition to this, in the case of an autonomous vessel such as the one posited in our example, there is the potential for liability on three other parties.

(i) The RCC.

While a vessel is under the direct control of a shore station, there is no doubt that the operators of the latter entrusted with her navigation and control owe a duty of care to prevent collisions with other vessels or installations. They would thus face potential liability for damage caused if, for instance, (a) the employee in charge failed to take proper steps to keep a remote look-out or otherwise avoid the risk of collision; (b) they failed to provide their employees with proper training in how to handle emergencies, with the result that a collision occurred; or (c) they failed to maintain adequate equipment, or to keep equipment they did have properly tested according to reasonable professional standards.

In addition, there might also be liability even where the vessel was sailing entirely autonomously, at least if the shore station had the ability to retake control in an emergency. It seems likely that the station would owe at least some duty to monitor a vessel in case an emergency situation arose requiring such a takeover, and if it did to take reasonable steps to regain control and mitigate the risk.

⁴⁰ The effect of this provision is described in some detail in Marsden & Gault, *Collisions at Sea* (15th ed), Paras.8-24 – 8-33.

⁴¹ In addition to the above, there is also a special strict liability regime for pollution caused by bunker oil and heavy oil; carried in bulk, but we are not concerned with those here.

(ii) Maintainers of control equipment.

Control from a shore station in the nature of things demands the use of specialised and complex equipment, comprising (for example) computer hardware, servers and software and devices capable of maintaining reliable communication between ship and shore. In so far as it can be shown that the collision was caused by failure of such equipment or hardware, and that this failure was due to the negligence of those who were tasked with maintaining it, then the latter will in principle be liable for any damage resulting.

(ii) Product liability.

In addition, there is the possibility of a product liability suit. This is dealt with below.

26. In our view, regulatory updates are essential in a number of areas so as to allow the law to take proper account of MASSs.

(i) Owners may unjustifiably escape liability to other vessels and shore installations.

Except as regards liability for loss or damage to cargo on board the ship in question, owners and operators of vessels are liable for the negligence of their own employees, but not for that of independent contractors or their workers. Ships' crews are employees, while RCCs are independent contractors. This means that the same act of negligence – say failure to keep a proper look-out – will make the owner liable if committed by a crew member, but not if committed by a remote officer. We see this as an indefensible anomaly. In our opinion the law needs to be changed so that the owner becomes liable for the negligence of the RCC's employees. This change will largely assimilate the positions of the owners of uncrewed vessels to those of crewed vessels, the latter being liable for the acts of those in control of the vessel, though not for the negligence of third parties such as repairers and service providers. Thus the owners of MASSs will be liable for the negligence of those in direct control of the vessel; but they will not be liable for that of independent repairers, nor for providers of equipment to the RCC, nor for failure of communications more generally. Apart from their liability for the negligence of RCCs, they will only be liable for the fault of their own employees. Where both owner and RCC are liable, the law should equally be changed to make it clear that there can be adjustment as between owners and the shore station, and for contribution between them.

(ii) The standards of Colregs.

Much of the determination of fault in a collision context depends, in practice, on their application and whether they were broken.

Colregs were drafted without reference to autonomous vessels. Many of their requirements, for example lights to be shown by vessels, can be carried across easily: some, such as the precise rules relating to overtaking, crossing and narrow channels, are if anything better suited to mathematical than human following. But regulatory change is needed for some others.

Notably the requirement for the keeping of a proper look-out under Reg.5 of Colregs clearly assumes a look-out by those on board; so too the requirement to proceed at an appropriate speed under Reg.6, when it refers to the state of visibility and local factors that that may impair it. In our view, three things must be made clear by amending legislation. One is that references to a proper look-out comport, in the case of a MASS under the control of an RCC, such a lookout as is reasonable to expect from a reasonable controller in respect of a vessel properly equipped with the correct on-board sensing equipment, etc. Secondly, visibility should be defined in the case of an autonomous vessel to mean visibility available to a reasonable shore-based controller. Thirdly, it should be stated that in so far as is practicable, the scope and range of any “virtual” look-out should be no less extensive than that which would have obtained had the relevant lookouts been an onboard crew.

Table 2

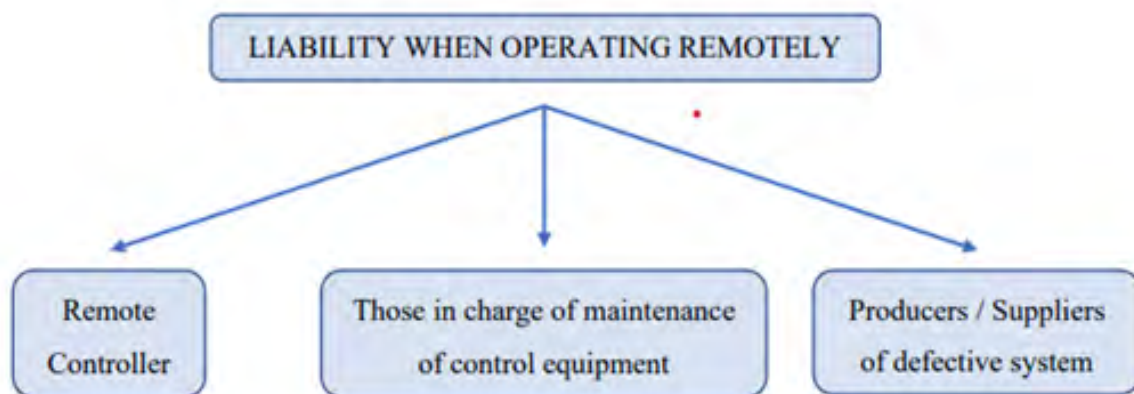
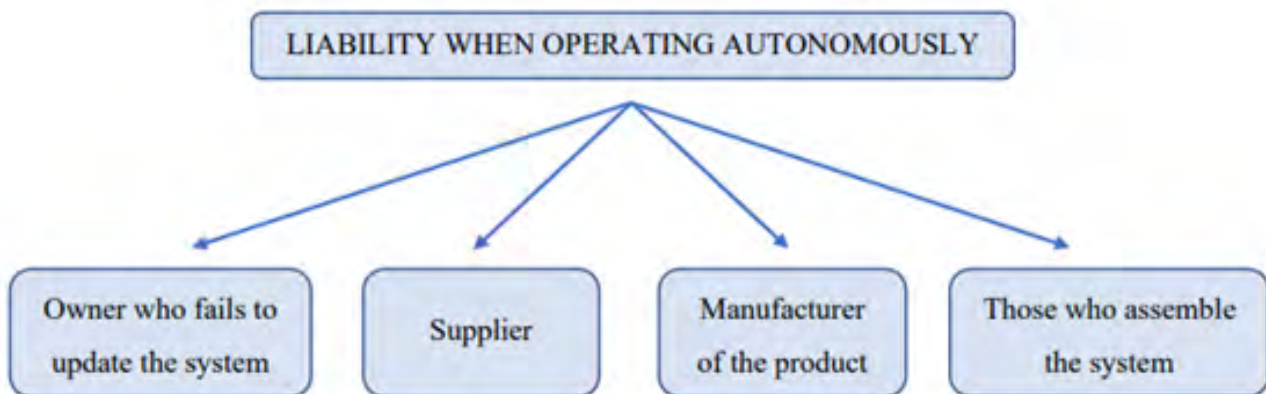


Table 3



(E) Liability relating to Navigation: Cargo Damage etc

27. This section sets out the law of England and Wales on the potential liabilities of ship operators and remote controllers for damage to cargo on board. The present law again is complex, but is summarised as follows.

(i) In general. As regards cargo loss or damage, the liability of the ship operator depends on the terms of the contract of carriage. If this is contained, as it often is, in a bill of lading governed by the Hague-Visby Rules,⁴² then the operator is essentially liable in two cases: (1) where it fails to take proper care to load, stow and look after the cargo,⁴³ and (2) where at any time before the beginning of the voyage it fails to show due diligence to ensure that the carrying vessel is seaworthy and fit to carry the cargo.⁴⁴ It should be noted that both these duties are referred to in law as “non-delegable”: that is, the ship operator is liable not only for its own fault, but for that of independent contractors employed by it.⁴⁵

Note, however, that this is balanced by two immunities. The ship operator is not liable for navigational fault (“act, neglect, or default of the master, mariner, pilot, or the servants of the carrier in the navigation or in the management of the ship”), even where cargo is lost or damaged as a result; nor is it liable for loss or damage caused by fire, unless due to the fault of its senior management.⁴⁶

Where carriage is governed by a voyage charter, liability depends on the terms of the charter. Very often the charter will contain similar terms to the above; but freedom of contract prevails here, and on occasion liability may be more limited.

(ii) Liability to cargo interests: the position of autonomous vessels and shore stations. There is no special rule for autonomous vessels here, but the application of the existing rules may give rise to slightly unexpected results.

The ship operator. As regards the duty to look after the cargo and provide a seaworthy ship, the operator will be liable not only for its own negligence but also for any fault by the shore station employed as an independent contractor (see above). This can be significant. If, for example, the shore station in programming a voyage fails to plan it properly so as to avoid hazards or heavy weather, this amounts to failure to provide a seaworthy ship; from which it follows that the ship operator will be liable for any resulting cargo loss. Again, imagine the shore station has control over hold ventilation, and fails to exercise it, with the result that in the tropics a cargo of wheat overheats and sprouts. This is failure to take care to look after the cargo, for which the ship operator will be liable.

⁴² The full legal effect of which is described in some detail, for those interested, in *Scrutton on Charterparties and Bills of Lading*, 24th ed, (Sweet & Maxwell, 2019) Ch.14

⁴³ Hague-Visby Rules, Art.III.2.

⁴⁴ Hague-Visby Rules, Art.III.1.

⁴⁵ *Scrutton on Charterparties and Bills of Lading*, 24th ed, (Sweet & Maxwell), Paras.14-46 and 14-51.

⁴⁶ See Hague-Visby Rules, Art.IV.2(a) and Art.IV.2(b).

The RCC. The position of the control station, which is not party to the contract of carriage, is less clear as a matter of law. Very possibly, however, it owes a general duty of care to the owner of cargo on board a vessel under its control. If so, any negligence on its part, such as failing to take care to ventilate cargo, avoid a collision or cause the vessel to sail round an area of heavy weather will make it liable to cargo interests for any damage suffered as a result. Ironically, this may mean that the centre will be liable to cargo in cases where the ship operator itself would not be, as with navigational fault.

28. Many of the rules on cargo liability carry over well to MASSs and RCC-controlled vessels. But in our view there is a need for one important regulatory change.

29. We see it as anomalous that there should be a possibility of cargo claims lying against shore-based controllers when they would not lie against a carrier itself because of the terms of the contract of carriage. It is our view that legislation should make it clear that any defence or limitation of liability which would have been available to a carrier may also be invoked by a shore-based controller.

(G) Limitation of Liability

30. In maritime law, the shipowners and certain others connected with the operation of a ship have traditionally enjoyed a right to limit their liability when facing maritime claims from third parties. Although this privilege has often attracted criticism, it provides the backbone of the liability regime for maritime claims. The ultimate beneficiary of such regime is liability insurers as such limitation enables them to calculate their maximum exposure in case of a maritime incident concerning the vessel they provide insurance cover for.

31. The UK is party to the Convention on Limitation of Liability for Maritime Claims 1976 as amended by the 1996 Protocol (known as the LLMC 1996).⁴⁷ Under this regime, the right of limitation is afforded to “shipowners”, “salvors” and “persons for whose acts the shipowner or the salvor responsible”. The registered owner, the charterer and the operator of a seagoing ship are deemed to be within the definition of a shipowner for the purposes of this regime so they are also entitled to limitation of liability.⁴⁸ When it comes to our remote controlled vessel (with the ability for autonomous navigation) completing its journey from Hull to Swansea, a number of issues emerge:

(i) Would it be possible for this craft to limit its liability under the LLMC 1996? The Convention does not define a “ship”; but the MSA 1995 does, stating that “ship” includes “any structure (whether completed or in the course of completion) launched and intended for use in navigation as a ship or part of a ship”. As such the definition is similar to that in s. 313 of the same Act, regarding a “ship” as “every description of vessel used in navigation”, save that an intent to use the vessel in navigation also suffices. To that extent, in so far as s. 313 includes autonomous vessels, so does Schedule 7 providing for the right to limit. On that basis, we do not believe this creates any difficulty.

(ii) A more difficult question is whether an RCC or those working at a RCC would be entitled to limit their liability in case of a casualty. We believe that it is within the spirit of the Convention that where immediate operation of a vessel is entrusted to any third party, that third party should be entitled to limit. Put differently, it is our view that the term “operator” in the Convention should be construed to include those in control of the ship in an RCC or the RCC itself.

⁴⁶ This has been implemented into English law by ss. 185-186 and Schedule 7 of the Merchant Shipping Act (MSA) 1995. The limits have been amended by the MSA 1995 (Amendment) Order 2016, SI 2016/1061.

⁴⁷ Article 1.2 of the LLMC 1996..

(iii) Another point to consider with regard to limitation is the position of a shipowner/operator. The right of limitation is not indefinite and might be lost in some instances. Under the LLMC 1996, for example, a person liable shall not be entitled to limit his liability "if it is proved that the loss resulted from his personal act or omission, committed with the intent to cause such loss, or recklessly and with knowledge that such loss would probably result."⁴⁹ Unless this test is amended, it is submitted that it will be virtually impossible to break the limits if a programming or software error causes a collision between a vessel in autonomous navigation mode and other vessels. In that scenario, it will be rather difficult if not impossible for third parties to demonstrate the personal act or omission of the shipowner/operator. The outcome will probably be the same even if ship managers fail to upload software updates onto the system, as in most instances such a conduct will fall short of "recklessness"⁵⁰ required to break the limits.

32. Last but not least, it is clear that manufacturers, such as software producers and programme designers, will not be able to limit their liability under LLMC 1996 when a recourse action is brought against them by the shipowner or by a third party involved in a collision for malfunction of parts manufactured by them. Whether the right of limitation of liability should be extended to such parties is ultimately a political decision. But we would point out that if it is not, the liability of the builder of an autonomous vessel, or the manufacturer of the systems used to control the vessel, will be higher than the liabilities faced by the shipowner itself. This might have serious implications in insurance arrangements and cost of liability insurance that manufacturers would need to purchase.

⁴⁹ Article 4. The same test also applies in other maritime conventions, such as International Convention for the Unification of Certain Rules of Law relating to Bills of Lading 1968 and Convention relating to the Carriage of Passengers and their Luggage by Sea 1974/2002.

⁵⁰ Recklessness is understood to be "a state of mind stopping short of deliberate intention, and going beyond mere inadvertence". See, *R. v. Lawrence (Stephen)* [1981] 1 All ER 974, at p. 978, per Lord Hailsham.

III. OTHER LEGAL MATTERS

(A) The Right of Arrest

33. In a number of situations a person with a claim against the owners or operators of a vessel may have a right to enforce that claim by arresting either that vessel, or a sister-ship in the same ownership. This right can be important, in that a person arresting a ship becomes, in common with anyone else with a right to arrest her, a secured creditor and therefore at least partly protected if the owner is insolvent. The situations where arrest is allowed are listed in s.20 of the Senior Courts Act 1981. The more significant ones are claims for salvage and towage, and for damage done by a ship; cargo claims; claims for injury suffered on board a vessel; claims for wages by master and crew; claims arising out of the supply of commodities such as bunkers; and claims arising out of charters.

34. The rights of arrest were last updated legislatively in 1981, well before the advent of MASSs. Nevertheless, most can be applied straightforwardly to the kind of autonomous vessels imagined in this report. Although the right of arrest is limited to “ships”, there is no difficulty in applying the legal definition of a “ship” (“any description of vessel used in navigation”)⁵¹ to an autonomous or uncrewed vessel such as the one in our example. Nor is there any problem with many of the specific claims. A claim for bunker supply, or salvage, or towage, is of exactly the same nature whether it relates to a ship with or without a crew on board; so too a claim for breach of a charterparty. But a few could cause problems: see below.

35. We take the view, however, that there is a need for legislative and/or regulatory change in a few cases, namely (i) claims for “damage done by a ship”; (ii) claims for loss of life or personal injury suffered in consequence of ship operations; (iii) claims for fees due to control centres; and (iv) claims for wages by the master or crew of a ship.

(i) Claims for “damage done by a ship.” (Senior Courts Act 1981, s.20(2)(e)). Under the present law the concept of “damage done by a ship” is interpreted as covering cases where the damage is due to the negligence of those in possession of the vessel, such as an owner, operator or bareboat charterer, or their employees.⁵² It is not clear whether such a right would arise where control of a vessel has been delegated to persons not on board, such as a third-party control centre ashore. We take the view that a right of arrest should be available in such a case, and that the 1981 Act should be amended accordingly. It should in addition be made clear that the additional security afforded by a maritime lien over the vessel for damage done cannot be denied merely because the relevant fault is that of those at a shore-based control centre.

⁵¹ See s.24(1) of the 1981 Act.

⁵² A. Tettenborn & F. Rose, *Admiralty Claims* (Sweet & Maxwell, 2020), Paras. 2-21 – 2-30.

(ii) Claims for loss of life. (Senior Courts Act 1981, s.20(2)(f)). Section 20(2)(f) allows arrest for any claim described as follows:

“any claim for loss of life or personal injury sustained in consequence of any defect in a ship or in her apparel or equipment, or in consequence of the wrongful act, neglect or default of—

(i) the owners, charterers or persons in possession or control of a ship; or

(ii) the master or crew of a ship, or any other person for whose wrongful acts, neglects or defaults the owners, charterers or persons in possession or control of a ship are responsible,

being an act, neglect or default in the navigation or management of the ship, in the loading, carriage or discharge of goods on, in or from the ship, or in the embarkation, carriage or disembarkation of persons on, in or from the ship.”

It is our view that for the avoidance of doubt, legislation should confirm that, for the purposes of s.20(2)(f), the words “master or crew” should be interpreted as including any persons from time to time in control of a vessel from a shore control station.

(iii) Claims for sums due to RCCs. Under s.20(2)(m) there is a right of arrest in respect of “any claim in respect of goods or materials supplied to a ship for her operation or maintenance.” This has been interpreted as including at least some supplies of services to a vessel, such as stevedoring or crewing agency services.⁵³ It would probably be construed as also applying to shore control services, but the matter cannot be regarded as beyond doubt. Legislation should make it clear that this is indeed the case.

(iv) Claims for wages. Under s.20(2)(o) of the 1981 Act there is a right to arrest a ship, and in addition a maritime lien against the vessel herself, in respect of “any claim by a master or member of the crew of a ship for wages (including any sum allotted out of wages or adjudged by a superintendent to be due by way of wages)”. What is not clear is whether this would apply to controllers in a shore station. We take the view that it should not. The right of crew to arrest a ship for wages seems to us to be based on the assumption that seafarers physically on board a vessel, perhaps far from home, need special protection in this respect. We do not think that any such need applies to remote shore controllers, and would urge that, by way of clarification, statute should provide that such persons shall not be regarded as master or crew for the purposes of s.20(2)(o). We would also call for confirmation that such persons are not entitled to a maritime lien on the vessel.

⁵³ A. Tettenborn & F. Rose, *Admiralty Claims*, (Sweet & Maxwell, 2020), Para. 2-43.

(B) Product Liability

36. Liability for marine casualties is normally thought of in terms of suits brought against shipowners and charterers. Typical are cargo claims against the carrying vessel, and claims arising out of collisions brought against vessel owners by the owners of other vessels damaged, together with crew and others injured aboard those other vessels.

37. But these are not the only possible claims. It is possible to sue others as well as vessel owners and operators. In particular, one chance of potential defendants, including in particular the producers of safety or control equipment, and for that matter (at least theoretically) shipbuilders. Moreover, as will appear, once control of a vessel passes from crew onboard to operators ashore the liability of third parties, including product liability, may become much more important. The law is briefly summed up below.

(i) Negligence liability.

There is no doubt that the producer of any item, including a compiler of computer software, owes a duty of care to anyone likely to suffer damage or injury as a result of a defect in it. If the product has been negligently manufactured, then unless there is a probability of intermediate inspection the manufacturer will be liable to anyone suffering foreseeable injury or property damage as a result.⁵⁴

A similar rule applies to those elsewhere in the distribution chain, such as distributors and suppliers: if a company distributes an item it ought to know is dangerous, or negligently installs it in such a way that damage is foreseeable, it is potentially liable for that damage.

(ii) Strict liability.

In some cases there is liability for damage done by defective products independently of fault. Under Part I of the Consumer Protection Act 1987, reproducing an EU Directive⁵⁵ and still in force despite Brexit, the producer of any product, and anyone importing it into the United Kingdom, is liable to anyone suffering death or personal injury as a result of that product being unsafe: that is, as a result of it not having that degree of safety which persons generally are reasonably entitled to expect. Negligence does not need to be shown; merely defectiveness, and injury suffered as a result.⁵⁶ It should be noted, however, that this liability is subject to a number of restrictions. It only applies to the producer of a physical product, and not to computer software (though where defective software is incorporated into a physical product and causes it to malfunction the latter may itself be defective as a result). And it only applies to defects causing death or personal injury: damage to commercial property, such as ships, cargoes, platforms or harbour installations, is excluded.⁵⁷

⁵⁴ The law on this is described in full in Clerk & Lindsell on Torts, 23 ed, (Sweet & Maxwell, 2020), Paras.10-08 – 10-44.

⁵⁵ Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products.

⁵⁶ See Clerk & Lindsell on Torts (23 ed), (Sweet & Maxwell, 2020) paras.10-45 – 10-91.

⁵⁷ There is theoretically liability for damage to non-commercial property, but this is of little relevance here

38. Both these heads of liability are potentially significant in the case of our example of an autonomous vessel sailing through UK territorial waters between Swansea and Hull. For example:

- (i) A refrigerated container cargo is destroyed when the temperature in the container unexpectedly rises. The cause is a glitch in negligently-written control software, which prevents temperature readings reaching the control centre to be monitored (or causes adjustment instructions entered onshore not to be transmitted to the vessel and given effect). The writer of the software is potentially liable.
- (ii) A collision occurs between the autonomous vessel and another ship, causing extensive damage to the latter and badly injuring one of her crew. The cause is the failure of a negligently-manufactured onboard sensor on board the autonomous vessel (or a negligently-made servo which would otherwise have caused a change of course). The manufacturer concerned is likely to face liability.
- (iii) A collision occurs between the autonomous vessel and another ship, causing extensive damage to the latter and badly injuring one of her crew. The cause is the failure of a defective engine control mechanism which the person supplying it had reason to know to be an unreliable product. The supplier is potentially liable.
- (iv) A collision occurs between an autonomous vessel and another ship as above, damaging the latter injuring a crew member. The cause of the collision is that the control station at a critical moment loses control of an autonomous ship as a result of an electric "fault" which disabled the controlling computer. An adequate over-voltage protector which would have prevented this could have been built into the relevant hardware, but the assemblers had negligently failed to do this. The assemblers are likely to be liable.
- (v) Imagine, for example, that a crew member on a ship is killed or injured in a collision when an autonomous vessel loses control and hits his own vessel. It is quite possible that (s)he, or her/his estate, may be able to prove that the casualty occurred because of a defect in any one of numerous pieces of equipment or elements of the system. Examples include any of the control or sensing equipment on the autonomous ship; communication equipment on that vessel or in the shore station controlling her; or the detailed control hardware in the latter place. In every case the producer of the equipment, or in the case of equipment imported into the UK the importer of it, is potentially liable for the injury or death.

39. In our view, in order to accommodate MASSs within the scheme of product liability, there is a need for a number of legislative and/or regulatory changes.

(i) The geographical scope of the Consumer Protection Act 1987.

It is unclear what the territorial extent of the Consumer Protection Act 1987 is.⁵⁸ In particular, does it apply to injury suffered on the high seas (assuming that the vessel in our example briefly strays outside territorial waters), or outside the UK land mass but within UK territorial waters? And does it apply to goods produced abroad? It is our view that this matter needs to be clarified. In our opinion, it should be made clear by statute that the Act extends (a) to any injury suffered in UK territorial waters, and (b) to defective products wherever manufactured. Thus where injury is suffered in UK territorial waters because of a malfunction in defective equipment in a control centre abroad, it should be possible to hold the manufacturer strictly liable wherever the equipment was produced. Marine casualties are, after all, in their nature transnational; and in the context of autonomous ships the positioning of the control centre (or centres) is likely to be entirely arbitrary.

(ii) The applicable law in product liability cases.

The present rules about whether English law, or some foreign system, applies to a product liability claim are entirely inappropriate to the context of autonomous (or for that matter any) shipping law. Contained in retained EU legislation known as the Rome II Regulation,⁵⁹ they essentially say that English law applies only to cases where steps were taken to market the offending product in the UK.⁶⁰

This is in our view wholly inappropriate in the context of claims brought in respect of damage caused by defective products aboard a vessel, or products being used or deployed in an autonomous vessel control centre. We would urge that, in the context of claims for damages arising out of a marine casualty, it should be stated that the rules of English law apply whenever the casualty took place in England or its territorial waters, and wherever the offending property was at the time of the casualty.

(iii) Limitation of liability.

We argue elsewhere that the right to limit liability which presently inheres in shipowners and charterers is too narrow. It is our view that it should be extended to product liability claims. For details see paragraph 32, above.

⁵⁸ It has been decided by the High Court that it does not apply to injury caused in a foreign country (see *Allen v Depuy International Ltd* [2014] EWHC 753 (QB); [2015] 2 W.L.R. 442); but beyond that there is no guidance.

⁵⁹ Regulation (EC) No 864/2007 of the European Parliament and of the Council of 11 July 2007 on the law applicable to non-contractual obligations.

⁶⁰ See Art.5 of the above Regulation.

(C) Criminal Jurisdiction

40. The jurisdiction of English and Welsh courts over criminal offences is based on the principle of territoriality that requires the commission of the crime (wholly or partially) within England and Wales,⁶¹ including their territorial waters.⁶² But it also extends further. The courts have jurisdiction to try offences committed on, under or above an offshore platform in designated areas or “any waters within five hundred metres of any such installation”.⁶³ In addition, acts in relation to person or property done by seamen employed on a UK ship may be tried in England wherever they occur;⁶⁴ and the same goes for offences under the Merchant Shipping Act committed anywhere by British citizens, and by non-British citizens aboard British vessels.⁶⁵

41. One important issue to note is that offences committed by foreign nationals on board foreign ships within English territorial waters are only to be prosecuted if the Secretary of State consents.⁶⁶ Such procedure satisfies Article 27 UNCLOS which prohibits the exercise of criminal jurisdiction of the coastal State “on board a foreign ship passing through the territorial sea to arrest any person or to conduct any investigation in connection with any crime committed on board the ship during its passage”, save only for a limited type of situations mentioned therein.

42. In our scenario, there is no extraterritorial element as the *MV Albion* is a British registered vessel operating exclusively within the territorial waters of England and Wales and controlled by a remote-control centre in Wales. Its operation falls squarely within the ambit of English criminal laws.

43. Having said that, the fact that the RCC, being in Swansea, is subject to the jurisdiction of the English or Welsh criminal courts is only the beginning of the story as several maritime-related criminal offences are linked to the behaviour of the master or a seaman.⁶⁷

44. First, s. 58(2) of the MSA creates a criminal offence of conduct endangering ships, structures or individuals which is deliberate, negligent or drink-induced. It is addressed to the master of, or any seaman employed in, a UK ship or in a non-UK ship that is in a UK port or within UK waters while proceeding to or from such port.⁶⁸ However, this provision is of limited use in the case of a MASS, since an offence is only committed if the defendant is at the time “on board his ship or in its immediate vicinity”, which will almost always not be the case in respect of acts or omissions taking place in a RCC. It is a big stretch to argue that a remote operator in Swansea is in the vicinity of a ship sailing from Hull to Plymouth.

⁶¹ *R v Harden* [1963] 1 QB 8 where a conviction for the offence of obtaining property by false pretences was quashed because the property was obtained in Jersey. For these purposes not only the Channel Islands, but Scotland, Northern Ireland and the Isle of Man are outside the jurisdiction of the English courts: M Hirst, *Jurisdiction and the Ambit of Criminal Law* (OUP, 2003), at 61.

⁶² s. 2 of the Territorial Waters Jurisdiction Act 1878.

⁶³ s. 2 of the Criminal Jurisdiction (Off shore Activities) Order 1987 (SI 1987 No. 2198) and s. 10 of the Petroleum Act 1998.

⁶⁴ Merchant Shipping Act 1995, s. 282

⁶⁵ Merchant Shipping Act 1995, s.281

⁶⁶ See s.3 of the Territorial Waters Jurisdiction Act 1878. This limitation is now required by Art. 27 of UNCLOS, which generally prohibits the exercise of criminal jurisdiction of the coastal State “on board a foreign ship passing through the territorial sea to arrest any person or to conduct any investigation in connection with any crime committed on board the ship during its passage”.

⁶⁷ We focus on marine-specific criminal offences in this report, yet it is possible that offences under general criminal law, such as manslaughter and criminal damage under the Criminal Damage Act 1971 might also be relevant.

⁶⁸ See s. 58(1) MSA 1995

45. Secondly, there is s.58(4) MSA, dealing with neglect of duty. This has a slightly broader scope of application and does not require presence on or near the vessel. If the person in an RCC with control of a vessel is regarded as a master, which we consider likely, this would be apt to catch the negligent controller. But it might well not catch anyone else, since it applies only to the “master of, or any seaman employed in,” a vessel;⁶⁹ and it might well be argued that a subordinate controller in an RCC was neither a seafarer nor employed in a vessel.

46. Thirdly, s.98(1) of the MSA 1995 provides that the master and the owner of the ship are guilty of an offence if a ship which is in a UK port or a UK ship is unfit to go to sea without serious danger to human life (unless they show that steps had been taken to effect repairs before she put to sea). This provision does not require the master to either be on board or in the vicinity of the dangerous ship, making it arguable that a remote operator falls within its ambit, subject to being given status equivalent to that of the master. Similarly, the owner might well be held liable under this provision or the operator; indeed, s.98(2) of the MSA casts the net wider by extending the ambit of the provision to any person who has assumed the responsibilities of the owner with respect to the matters relevant to the safety of the ship by agreement with the owner.

47. Our scenario has no extraterritorial elements, yet it is expected that the operation of MASSs will eventually involve multiple jurisdictions and the High Seas, where the exercise of criminal jurisdiction becomes complicated. Without going into detailed analysis, English criminal law can only rarely extend its ambit to offences committed abroad, even by British nationals. This is a complex subject and we do not discuss it here. Suffice to say that the regulators should consider carefully whether it should be allowed for a MASS operator to be based outside the UK. As we indicated, this will not only create significant legal difficulties and no doubt international law issues will emerge as to what extent criminal sanctions could be imposed and enforced for those operating MASS extra territorially.

48. While clarification about the status of remote operators as masters or seamen would bring legal certainty, the criminal law provisions of the MSA, by and large, do not require an overhaul in order to fit into the autonomous era. Having said that, what might be required is the creation of tailor-made offences reflecting the division of duties in a RCC as well as the new manners of operating vessels.

⁶⁹ See s. 58(1) MSA.

(D) Unmanned Aircraft Systems (UAS)

49. The UK Civil Aviation Authority (CAA) has implemented rules about the operation of civil Unmanned Aircraft Systems (UASs), commonly known as “drones”, and the licensing of their remote pilots.⁷⁰ We believe that a short introduction to them gives insight into the future regulation of MASSs especially with respect to remote pilots and RCCs. Although the operating environments of MASSs and UASs are different, they have several conceptual issues in common that the CAA has (or is in the process) of addressing regarding UASs. Its lead can potentially inform the discussion about the regulation of MASSs in the UK.

50. The rules on the operation of civil UASs in the UK are divided in three categories which are guided by the following principles. They are

- (i) operation-centric in that they reflect the diverse environments where UAS operate;
- (ii) risk-based in that they focus on the risk created by the operations; and
- (iii) performance-based in that they identify the required level of performance without prescribing exact means to achieve it.⁷¹

51. Guided by them the UK CAA has established the Open Category, the Specific Category and the Certified Category of operations. A short synopsis of them follows.

51. Open Category

- (i) For UAS that pose little risk to third parties, a remote pilot is required merely to pass an online theory test that enables her/him to hold a Flyer-ID. They must also register as a UAS operator and thereby become responsible for the safe operation of the UAS.⁷²
- (ii) If the UAS is to be operated within residential, commercial, industrial or recreational areas and in close proximity to uninvolved persons, the remote pilot is also required to obtain an A2 Certificate of Competency (theory test) that “assures an appropriate knowledge of the technical and operational mitigations for ground risk”.⁷³ This certificate enables the remote pilot to reduce the minimum horizontal distance from uninvolved people to 30 metres and to 5 metres if the UAS is operated in the “low-speed” mode.⁷⁴

⁷⁰ In the UK, UAS operations are governed mainly by retained EU law, namely the Implementing Regulation 2019/947 on the rules and procedures for the operation of unmanned aircraft (UAS Implementing Regulation) and the Delegated Regulation 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems (UAS Delegated Regulation), as well as the Air Navigation Order 2016. The UK CAA has also issued detailed guidance regarding UAS operations in the UK airspace in the form of UK CAA, CAP 722: *Unmanned Aircraft System Operations in UK Airspace – Guidance* (2020) (CAP 722).

⁷¹ See EASA, “Opinion No. 01/2018. *Introduction of a Regulatory Framework for the Operation of Unmanned Aircraft Systems in the ‘Open’ and ‘Specific’ Categories.*”

⁷² UK CAA, CAP 722: *Unmanned Aircraft System Operations in UK Airspace – Guidance* (2020), paras 1.5 and 4.2.3.1 (CAP 722).

⁷³ *Ibid.*, para 4.2.3.1.2.

⁷⁴ *Ibid.*, para 2.2.1.2.

(iii) If a UAS operator employs more than one remote pilot, the operator is required to “develop and produce procedures for in order to coordinate the activities between its employees; and establish and maintain a list of their personnel and their assigned duties”.⁷⁵ In the Open Category, operators are not required to obtain authorisation by the UK CAA, nor to submit a special declaration to the CAA regarding the safety of the UAS operation. UAS operated in the open category are not permitted to carry dangerous goods or drop any materials.

(iv) This rather lax regulatory approach is explained by the following two factors:⁷⁶

- o The Open Category is intended for UASs with limited operational capabilities. They have a Maximum Take Off Mass (mass of the unmanned aircraft, including payload and fuel - MTOM) of less than 25 kg and are to be operated within the Visual Line of Sight (VLOS) of the remote pilot and at an altitude of less than 120 m/400ft from the ground.⁷⁷

- o Also, UAS under the Open Category will bear (as of 1 January 2023) a class identification label, ranging from C0 to C4, which corresponds to product safety requirements and determines how close the machine is permitted to fly to uninvolved people.⁷⁸

53. Specific Category

(i) For UAS operations outside the Open Category, the operator is required to obtain an operational authorisation from the UK CAA by performing a risk assessment in the form of an Operating Safety Case (OSC). The OSC must describe the characteristics of the UAS operation, identify potential risks to third parties or property, and propose adequate mitigating measures. The UK CAA requires operators to detail the role and responsibilities of the flight team, namely, commander, remote pilots, observers and other support staff, such as ground station operators, payload operators, radio operators etc.⁷⁹ In addition, it requires a statement as to whether the UAS will be operated within VLOS, extended VLOS or Beyond the Visual Line of Sight (BVLOS) basis and also the procedures to be followed in cases of emergency recovery, loss of control link and how to avoid aircraft.⁸⁰

(ii) The licensing requirements of remote pilots in the Specific Category depend on the nature of the activity authorised and are identified within the authorisation.

⁷⁵ *Ibid.*, para. 4.1.2.1.

⁷⁶ For a detailed critique see G. Leloudas & M. Chatzipanagiotis “Use of Unmanned Aircraft Systems in a Maritime Context: Operational, Regulatory and Legal Issues” in B Soyer and A Tettenborn (eds) *Disruptive Technologies and Climate Change in Shipping* (Informa Law from Routledge, forthcoming 2022).

⁷⁷ The UK CAA presumes that the VLOS requirements are satisfied when the UAS is flown up to a distance of 500 metres horizontally from the remote pilot which can be extended by the use of observers under strict conditions - see CAP 722, para 2.1.1.

⁷⁸ *Ibid.*, para. 2.2.1.2.

⁷⁹ UK CAA, CAP 722A *Unmanned Aircraft System Operations in UK Airspace – Operating Safety Cases* (2019), Section 1, para 3.3 (CAP 722A).

⁸⁰ CAP 722, para. 2.4.3.

(iii) It is possible that a remote pilot will only be required to obtain a Flyer-ID with an A2 Certificate of Competency, yet in most cases the UK CAA would require obtaining the General VLOS Certificate which is an “one stop qualification that satisfies the remote pilot competency requirements for VLOS operations”.⁸¹ The test consists of both a theoretical and a practical flight test and additional examination modules can be added depending on the complexity of the UAS operation. It is important to note that this certificate is not sufficient for BVLOS operations where the remote controller is not in sight of the UAS, for which a Remote Pilot Licence or a manned aircraft pilot’s licence is required (see below for more information).

54. Certified Category

(i) To regulate UASs that operate at a high level of risk, i.e. posing an equivalent risk to that of manned aviation, the Certified Category has been created. For operations falling herein authorisation is provided through the certification of the design, production and maintenance of the UAS, the certification of the UAS operator and by imposing more stringent requirements for the licensing of remote pilots.

(ii) The requirements of the certified category apply to UASs which (a) have a characteristic dimension of at least 3 m and are designed to be operated over assemblies of people; (b) are designed for transporting people; (c) are designed for transporting dangerous goods; or (d) are considered by the competent authority to pose operational risks that can only be adequately mitigated through the certification process.⁸²

(iii) The remote pilot is expected to hold a manned aircraft’s pilot licence “with appropriate mitigation related to the operation of the particular unmanned aircraft”.⁸³ The expectation is that remote pilots in this category will require to obtain an RPL when the exact requirements are fully developed that are not expected until 2024 at the latest.

(iv) Until detailed rules are developed for the Certified Category, the UK CAA is requiring operators to comply with the rules applicable to manned aircraft regarding airworthiness, operations and licensing, such as the need for a type certificate and a certificate of airworthiness, which in practice requires vigorous and time-consuming efforts; the UK CAA expects that “the full suite of documentation, as expected for an equivalent manned aircraft operation, will be required”.⁸⁴

⁸¹ *Ibid.*, para 4.2.3.2.1.

⁸² Art 40(1) UAS Delegated Regulation and Article 6(1) UAS Implementing Regulation.

⁸³ CAP 722, para. 4.2.3.

⁸⁴ *Ibid.*, para. 4.1.2.1.

55. BVLOS

(i) One of the most pressing demands of commercial UAS operators in the UK is for the UK CAA to facilitate the operations of UAS in BVLOS mode. BVLOS operations do not require the remote pilot to maintain visual contact with the UAS during flight, enabling their operation for distances longer than 500m from the pilot and consequently the establishment of RCCs. Equally important is to allow such operations in non-segregated airspace, namely airspace that is shared with manned aircraft.

(ii) BVLOS operations are not prohibited by the current regulations (except for operations in the Open Category), but the UK CAA, in order to mitigate the increased risk of collisions, grants permissions only if one of the following three circumstances are satisfied:

- a Detect-and-Avoid (DAA) capability has been integrated into the UAS;
- the UAS operates in airspace that has been reserved for it, usually by means of establishing a temporary Dangerous Area (DA); or
- the operator provides clear evidence that the UAS flight poses “no aviation threat” and that the safety of persons and objects on the ground has been properly addressed.

(iii) While remote pilots in VLOS operations must comply with visual flight rules and have primary responsibility to avoid collisions,⁸⁵ a UAS in BVLOS mode must be able to perform an equivalent function in terms of detecting and avoiding collisions.⁸⁶ The UK CAA has stressed that installing live-feed cameras on board the UAS is not an acceptable mean of compliance with the DAA requirement. For the permission to be granted, the installed technology is required to take autonomous decisions by avoiding obstacles and generating flight paths.

(iv) It is expected that DAA technologies will pave the way for the frequent use of UAS in BVLOS mode and will eventually lead to their fully autonomous operation without any human intervention during flight.⁸⁷ Full level of autonomy is not currently permitted in non-segregated airspace as the UK CAA requires that the remote pilot shall always be “capable of immediately taking active control of the UA”.⁸⁸ At the same time, operations of UAS in BVLOS mode in non-segregated airspace must comply with Instrument or Visual Flight Rules (as appropriate to the flight in question) and the remote pilot is required to monitor the UAS performance and communications with Air Traffic Controller “in a timescale comparable with that of a manned aircraft” while making controllers fully aware that they are dealing with a UAS by including “the word “UNMANNED” on first contact with the ATS provider”.⁸⁹

⁸⁵ *Ibid.*, paras 3.6.1 and 3.6.4.

⁸⁶ UK CAA, “Beyond Visual Line of Sight in Non-Segregated Airspace Fundamental Principles & Terminology” (October 2020) <<https://publicapps.caa.co.uk/docs/33/CAP%201861%20-%20BVLOS%20Fundamentals%20v2.pdf>> accessed 5 October 2021.

⁸⁷ UK CAA, “Beyond Visual Line of Sight in Non-Segregated Airspace. Fundamental Principles & Terminology” (October 2020) <<https://publicapps.caa.co.uk/docs/33/CAP%201861%20-%20BVLOS%20Fundamentals%20v2.pdf>> accessed 5 October 2021.

⁸⁸ CAP 722, para. 2.4.2.

⁸⁹ *Ibid.*, para 2.4.1

56. International Operations of UAS

(i) In international law, rules applicable to UASs can be found in the 1944 International Convention on Civil Aviation (the Chicago Convention).⁹⁰

(ii) Article 8 of the Chicago Convention prohibits flights of pilotless aircraft over the territory of a contracting State without special authorisation from that State, while contracting States undertake to ensure the safety of such flights as to the risks posed to other airspace users. The territory of a State includes the land areas and its territorial waters.⁹¹

(iii) Due to this prohibition, UAS operations must comply with the licensing, certification and operational requirements of the State of operations. Inevitably, this arrangement makes the establishment of RCCs in a country other than the country of operation of the UAS a complicated process as requires dual permissions. Similarly, operating a UAS to a State other than the State of its registration or on a cross-border basis would require the granting of permissions from both the country of origin and the country of destination. The International Civil Aviation Organisation (ICAO) is currently “developing international SARPS covering Remotely Piloted Aircraft Systems which are conducting international Instrument Flight Rules (IFR) operations within controlled airspace and from aerodromes... The appropriate UK regulations will be adapted in accordance with these SARPS when they are completed”.⁹²

57. While the operational environments of UASs and MASSs are rather different, the rules of the UK CAA highlight that a one-size-fits-all approach in regulating autonomous modes of transport is not advisable. The tripartite division of the UAS rules reflects the different levels of risk envisaged in each category and allows the regulator to make tailor-made arrangements based on the risk profile of the proposed operation. This flexibility is essential to accommodate the rapid technological developments in the field and to encourage new type of operations (for example the use of UASs in the maritime field). While detailed rules in the Certified Category are not yet implemented, it is expected that the technological developments in the field of DAA will enable their drafting both at an international (ICAO) and a domestic level within this decade at which point the establishment of RCCs is expected to become a reality. As such, the CAA operates on an incremental basis, having created an overarching regulatory framework that motivates further research while enabling the creation of detailed rules once the technological risks are considered acceptable.

⁹⁰ Convention on International Civil Aviation, done at Chicago on 7 December 1944, in force since 4 April 1947.

⁹¹ Art 2 Chicago Convention.

⁹² CAP 722, para. 1.2.2.1.

IV. SUMMARY OF CONCLUSIONS

58. The main objective of this report is to illustrate the legal and regulatory difficulties that a MASS could encounter when navigating from Hull to Plymouth remotely controlled or navigating autonomously. Obviously, the analysis gets more complicated if the same vessel attempts to undertake a voyage outside the jurisdiction of the United Kingdom as in that case different international legal regimes would become relevant. However, that discussion is beyond the scope of this project.

59. In the concluding part, we would like to summarise our findings with reference to what legislators and regulatory bodies need to do to ensure a vessel like MV Albion could operate in UK waters safely and in the full knowledge of its legal standing with regard to civil and criminal matters.

60. It is worth noting that it will not be within the purview of one single regulatory body to effect all the recommendations made in this report. Below we shall highlight our main recommendations highlighting which regulatory body or bodies need to engage in their implementation.

61. Regulatory bodies, led by MCA, would need to consider safety and other technical requirements that need to be put in place. In particular:

- Defining technical and manning requirements (including training) for RCCs. It is also essential to define the legal status of those working at RCC and i) the role and function of each officer within the RCC; ii) how co-ordination between different units within the RCC will be achieved; iii) safety management system that needs to be put in place at the RCC to ensure safety.
- It is also essential to specify the design and technical requirements a MASS operating in UK waters should comply with.

62. Port and Competent harbour authorities need to specify:

- The conditions (technical and manning (including RCC operators)) that a MASS should satisfy prior to being given access to a particular UK port.
- How far there should be a derogation for the benefit of MASSs from requirements in byelaws that vessels in harbours should in various circumstances have someone on board.
- How the owners or operators of a MASS could fulfil the role of a "master"- essentially a person to whom notices required to be sent to the master can be communicated. It is also essential to define the legal status of such person- we are firmly of the view that any legal penalty, liability attaching to the "master" should attach to this person.

63. We also believe that legislative measures would be necessary on the following matters:

(a) Salvage

- There is a need for legislative intervention (i) to state that, for the purposes of the Salvage Convention, where a ship is uncrewed or under RCC control the term “master” shall include the person from time to time in control of her at a relevant control station; and (ii) to make it clear that operations carried out entirely on land may in a suitable case be classified as salvage.

(b) Navigation and collisions

- There is a need for legislative intervention (i) to provide that owners are liable for the negligence of RCCs and their owners even though the latter may in law be independent contractors; and (ii) to adapt the provisions of COLREGS on matters such as lookout to make sure they are appropriate for conditions on a MASS.

(c) Cargo claims

- There is a need for legislative intervention to make it clear that any defence or limitation of liability which would have been available to a carrier may also be invoked by a shore-based controller.

(d) Right of Arrest

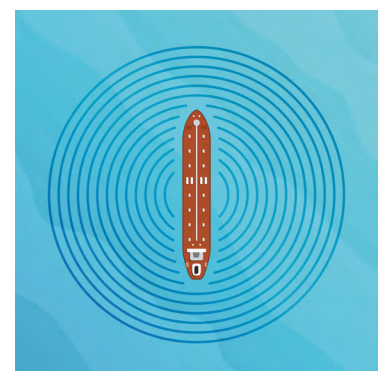
- We see a need for legislative intervention to clarify (i) that claims for “damage done by a ship” extend to damage done by a vessel under the control of a RCC; (ii) that claims for loss of life due to the default of the master or crew of a vessel should extend to vessels under RCC control; (iii) that there is a right of arrest for RCC dues; and (iv) that claims for wages do not encompass those employed on RCCs.

(e) Product liability

- Legislation should make it clear (i) that the 1987 Act applies to any injury suffered in UK territorial waters, and to defective products wherever manufactured; and (ii) that in the context of claims arising out of a marine casualty, the rules of English law apply whenever the casualty took place in England or its territorial waters, and wherever the offending property was at the time of the casualty.

64. We also believe that legislative interference would be necessary on the following matters:

- It is essential to create tailor-made criminal offences in the MSA reflecting the division of duties in an RCC and the remote operations of ships.
- Study the structure of the regulations regarding UAS to establish whether any lessons can be learned regarding the training and certification of remote controllers and MASS.



APPENDIX 1

Ongoing Main Autonomous Shipping Projects

Name: Yara Birkeland⁹²

Funded by: Yara and Kongsberg

When it will be ready: The hull of this vessel was launched in February 2020 and was delivered under tow to a shipyard in Norway in May of 2020. She was handed over to Yara in November 2020 and made her first voyage in November 2021. The vessel is currently fitted with a detachable bridge and is undergoing further development of its autonomous systems. It is planned to be launched later this year as a manned vessel and is currently being scheduled to enter fully autonomous operation in 2022.

What it will be used for: The range of this vessel will be somewhat limited. It is being planned to be operated between three ports in Norway, Heroya, Brevik and Larvik, and will be running commercially just for Yara products. This is a feeder container vessel with a cargo capacity of 120 twenty foot containers, operating at a service speed of 6 knots.

Project Outline: The Yara Birkeland is the world's first autonomous feeder container vessel. It has a length over all of 79.5m and will be propelled by two electrically powered azimuth pods and two thrusters. This is in many ways one of the most advanced unmanned vessel projects, however there are a few limitations. The max speed of 13 knots and the service speed of 6 knots for a vessel of this size shows the limits of electrically powered vessels operating at sea. The area of operation within 12 miles of the Norwegian coast is a further indication that this sort of propulsion system is not up to the challenge of operating further afield. Another reason for its area of operation is that will be fulfilling a very specific commercial purpose. Its small cargo capacity of 120 twenty foot containers is well below the average size of a comparable feeder vessel, which can carry between 300 and 1000.⁹³ This added to its slow service speed will make it significantly less efficient in terms of cargo carrying capacity, even over traditional feeder routes. The vessel is also due to be operated only within the control of the Brevik Vessel Traffic Service (VTS) area. It seems likely that this is so that VTS operators will have extra training to deal with vessels operating autonomously, in particular when it comes to other vessels using the same area. The ports themselves will need to be adjusted to accommodate autonomous operation, and are due to be fully automated. This will require significant infrastructure upgrades in all the ports being used. It is important to note that Yara are to use this vessel to relieve pressure on lorries operating between the three ports, and carry their cargo. The fact that there is only one stakeholder involved with support from the Norwegian government is why such a project is possible.

⁹² Kongsberg, "Autonomous Ship Project, Key Facts about Yara Birkeland" <https://www.kongsberg.com/maritime/support/themes/autonomous-ship-project-key-facts-about-yara-birkeland/> (last tested on 1 November 2021)

⁹³ <https://container-xchange.com/blog/feeder-vessels/> (last tested on 1 November 2021)

Name: Rolls Royce SVAN

Funded by: Rolls Royce and Finnferries

When it will be ready: Rolls Royce have already demonstrated autonomous operation of a ferry in Finland called the Falco.⁹⁴ However, it is currently being used to develop its “intelligent awareness” navigation⁹⁵ system that is in development.

What it will be used for: Currently this project is limited to small double ended car ferries operating between islands. The Falco is 53.8m in length and is powered by Rolls-Royce Azimuth thrusters. It is due to be used across a small route between Paranien and Nauvo in the Turku archipelago in Finland.

Project Outline: This is the development of an autonomous navigation system that can be retrofitted on to current vessels. In fact, whilst the use of the automated systems on the Falco looks to bring this project into the realms of projects such as the Yara Birkeland, the scope is perhaps more limited. Rolls Royce is developing its intelligent awareness navigation system, with four stages of implementation. The first will be an onboard advisory system, which simply provides enhanced situational awareness to the OOW, however it is ultimately the onboard crew who will execute any navigational actions. The second stage involves onboard control, the autonomous system will have a greater decision making role, however once again it will still be the OOW who approves any action. The third step is called “bridge zero” where the vessel is in full control of an autonomous system, however there will be a standby OOW who can be called to bridge should they be required. This can perhaps be more closely compared to unmanned machinery spaces. Full remote and autonomous navigation is the end goal of this project, however it is clear that Rolls Royce are looking to have a commercially viable system operating on larger vessels much sooner. The major advantage with these advanced decision making systems is that they can be retro fitted on to current vessels, however they are also likely to be expensive and will, at most, reduce crew by perhaps one or two. The initial outlay is likely to be much larger than any commercial benefits, and so will perhaps be more useful on vessels that require officers for other activities, or are engaged in high end safety critical activities. It is unlikely that this will be of much commercial interest to more traditional cargo vessels operating internationally.

⁹⁴ Royce, “Rolls-Royce and Finnferries demonstrate world’s first Fully Autonomous Ferry” <https://www.rolls-royce.com/media/press-releases/2018/03-12-2018-rr-and-finnerries-demonstrate-worlds-first-fully-autonomous-ferry.aspx> (last tested on 1 November 2021)

⁹⁵ The Maritime Executive “Rolls-Royce Launches “intelligent Awareness” Navigation System” <https://www.maritime-executive.com/article/rolls-royce-launches-intelligent-awareness-navigation-system>

Name: Mayflower 400⁹⁶

Funded by: Promare and IBM

When it will be ready: The vessel made a first attempt at an autonomous crossing of the Atlantic in July of this year, however this was aborted due to a machinery malfunction. The vessel is currently undergoing repairs before it makes a second attempt.

What it will be used for: The Mayflower 400 is one of a number of autonomous vessel projects designed to study the marine environment. These vessels will be able to spend significant time at sea collecting marine data, however it is likely that their area of operation will be mostly deep sea.

Project Outline: The Mayflower 400 is the first autonomous project to have tested on the high seas. Whilst the attempt was aborted, it is likely to be the first major project to navigate autonomously between two separate States, whilst also transiting international waters. The focus of this project is software related, IBM have developed advanced decision making systems that provide real time analysis based on inputted data. Interestingly, this software is very versatile and has been developed to be used in systems beyond autonomous shipping. The limitation of this project is that it is clearly being designed to develop smaller autonomous vessels that are there to collect ocean data. It's design is specifically to allow it to spend long periods at sea collecting data. It is only 15m long and so is not envisaged to be scaled up for operation as a cargo vessel. Once again, it is electrically powered with lithium batteries charged by solar power. It has two 20kW motors, and so its propulsion power is very limited. The space required for even this small amount of power is significant, as any attempt to scale up to a larger vessel would be difficult.

⁹⁶ <https://mas400.com> (last tested on 1 November 2021)

Name: Jin Dou Yun O Hao

Funded by: Chinese Government

When it will be ready: This vessel was successfully tested in December 2019 in a limited capacity. However it is part of a wider number of autonomous shipping projects supported by the Chinese government, with the aim to have autonomous vessels in operation by 2025.⁹⁷

What it will be used for: This particular project was a test in order to demonstrate the autonomous capacity being developed in China. The ship only carried one container across the bay in Guangdong. As such, it has no practical use itself, although it is the first step in a fast paced autonomous shipping community in China.

Project Outline: It is difficult to gain too much information about the type of software being used in these projects, as there is a certain amount of secrecy surrounding this. It is likely, however, that it uses similar principles to other autonomous shipping projects, namely inputs from radar, lidar, cameras etc into a decision making software. Presumably there will also be some machine learning. Indeed, much of the technology seems to be based on what has been developed elsewhere, in particular from Norway. What is interesting in China is that Chinese shipbuilders are already starting to integrate a capacity for autonomous operation into their new build vessels. The fact that China is one of the biggest centres for shipbuilding, with shipyards that are supported by the Chinese government, mean that there is huge access to resources for the development of autonomous shipping in China. China has this year launched a research vessel that can be operated autonomously or remotely. This vessel will still have onboard crew and it is planned to be used to launch further unmanned vehicles for scientific research. China is also developing a container vessel similar to the Yara Birkeland. Many of these projects have similarities to those been developed elsewhere, however what is particularly interesting is that they are all being developed in conjunction with each other. China is creating the world's largest test area for autonomous shipping in Zhuhai and is aiming to be a world leader in autonomous shipping.⁹⁸ With the resources available to them and the support of their large shipbuilding industry, this seems a very achievable goal.

⁹⁷ N. Chubb, "China will be a Leader in Autonomous Shipping by 2025" <https://thefius.com/china-will-be-a-leader-in-autonomous-shipping-by-2025/> (last tested on 1 November 2021)

⁹⁸ Maritime Executive "China to build Autonomous Ship Test Bed" <https://www.maritime-executive.com/article/china-to-build-autonomous-ship-test-bed> (last tested on 1 November 2021))

Name: ABB

Funded by: Maritime and Port Authority of Singapore

When it will be ready: ABB have already operated a tug by remote control in Singapore as a test project in April 2021.⁹⁹ It is hoped to test the vessel autonomously towards the end of this year. The project is part of the port's Singapore Maritime R&D Roadmap 2030,¹⁰⁰ with the aim to have fully autonomous berthing and cargo handling by 2025.

What it will be used for: These tugs will be used to remotely pilot Singapore harbour tugs, with orders placed for specially built tugs. They will aid vessels using the port, and are likely to be used in conjunction with remote pilotage. The aim is for them to be operating in autonomous mode to take up station for incoming vessel, and then under remote control when manoeuvring.

Project Outline: ABB Group are a major company in this area, and have numerous projects involving remote control and MASS. They are also a major propulsion leader, which may be useful as compared to some of the more "navigation" based MASS projects, such as Kongsberg. It is interesting to note that they are heavily pushing sustainable or electrical propulsion for large vessels, in particular Azipod propulsion. This is almost certainly a more realistic form of propulsion for MASS or remote control vessels than traditional slow speed engines. Indeed, if we look at any current MASS project, they are exclusively running on azipods or electrical motors of some kind, or even wind power. The problem here is that this limits the size of the vessels, and also means higher costs as generators require a higher grade of fuel than slow speed engines. This may become less of an issue in the future, as these lower grade fuels are being slowly phased out, but will certainly price many shipowners out of investing in autonomous technology. Cruise ships often use this type of propulsion, however cruise ships need electrical power throughout the ship and so routing power throughout the vessel becomes less of a problem and generators can be placed wherever. On cargo vessels, running lots of cabling around the vessel can only be done down the "Burma roads" or sides of the vessel, creating much less redundancy in terms of rerouting power in the event of any failure. All this serves as evidence as to the focus of ABB when it comes to their MASS projects, which are inland ferries in Finland and also tugs in the port of Singapore. The primary means of control is due to be a remote control operator working ashore, however as with any remote control system there will be an autonomous element. The reasoning behind this is that the operator can be "rested" when required to perform manoeuvres with the ship, although the main reason is probably that remote control will only be economically viable if one controller is able to operate multiple vessels. As such, the plan is for these vessels to navigate the waters of the port of Singapore autonomously to take up station, and to only be controlled remotely when connected to the vessel. These tugs are likely to have an onboard crew, who will be needed when passing lines to vessels entering the harbour, however it is felt that routine tasks will be able to be carried out by autonomous systems. In particular, it is likely that the onboard crew will be used in more of a maintenance role, and will have longer rest periods whilst taking up their station. The vessel's shore based operator will be monitoring the vessel from a shore based remote control centre. It is likely that they will be responsible for monitoring multiple vessels at the same time.

⁹⁹ ABB "ABB and Keppel O&M Reach Key Autonomy Milestone with Remote Vessel Operation Trial in Port of Singapore" <https://new.abb.com/news/detail/79622/abb-and-keppel-om-reach-key-autonomy-milestone-with-remote-vessel-operation-trial-in-port-of-singapore> (last tested on 1 November 2021)

¹⁰⁰ Singapore Maritime Institute, *Singapore R&D Roadmap 2030*, (Singapore, 2020)

Name: Wartsila

Funded by: Government of Finland/Finnpilot

When it will be ready: Trials are due to be started this year, with simulator based trials having already taken place. The aim is to be ready for remote pilotage at some point in 2025.¹⁰¹

What it will be used for: It will be used to replace onboard pilotage for certain vessels using ports in Finland. It is not due to replace all vessels, and is for the moment seen as providing flexibility in the event of bad weather or commercial pressures on pilotage services.

Project Outline: This is a reasonably well advanced project dealing with remote pilotage for vessels operating within Finnish waterways. It is a remote control system, with vessels being piloted from a shore based station, however as with any system there will be an autonomous aspect. The idea will be that vessels will be able to undertake the more simple parts of the route, such as straight legs, with pilots being able to monitor and step in at the more complicated areas, long turns, areas of shallows or strong tides for example. The benefits to shipowners from this type of project should become fairly clear straight away. Whereas with autonomous or decision support systems on larger vessels that remain fully crewed, the costs will probably outweigh the benefits as they will at most save perhaps on one deck officer, here the costs involved in pilotage can be enormous and removing them will be of great interest to ship-owners. Indeed, it is not just the costs, but also safety involved in embarking pilots out at sea. This can be a very risky procedure, especially in rough seas, and so the prospect of only embarking a docking pilot within striking distance of the dock will be of much more interest.

Of course, there are a few limitations as well. This project will require retrofitting of vessels and will require additional training for both the remote pilots and for seafarers operating under remote pilotage. It is not envisaged that this will be a system for all vessels arriving in Finland. Indeed, a simulation was run with a remote pilot in one simulator operating a vessel being navigated by a Master and Chief Officer in another simulator. Despite the fact that the Master and Chief Officer were familiar with the waters being navigated, and the fact that everyone involved was Finnish, there was a disconnect between the onboard crew and the remote pilot. These problems would be even greater if we were to introduce foreign nationals and crew unfamiliar with the surroundings into the mix. Already we can see huge language problems between vessels. The fact that communication will become so vital when using remote pilotage means that the capacity for things to go wrong is much greater. Indeed, the forced use of remote pilotage during the COVID pandemic has received a great deal of criticism from many P&I clubs.¹⁰²

¹⁰¹ Port of Turku, "Will Ships be piloted remotely in the future?" <https://aboard.portofurku.fi/en/2021/01/will-ships-be-piloted-remotely-in-the-future/> (last tested on 1 November 2021)

¹⁰² Standard Club, "Remote Pilotage – Perspective and risks to Consider" https://www.standard-club.com/fileadmin/uploads/standardclub/Documents/Import/publications/loss-prevention-industry-expertise-handouts/3314373-remote_pilotage_pdf.pdf (last tested on 1 November 2021)

In order to develop better forms of remote pilotage, this project has focused on the creation of a so called "port ecosystem". It seems that many of the early adoption of MASS will be within self contained bubbles. Yara Birkeland is an example, the various small ferries and the tugs in Singapore. Indeed, it would seem likely that areas where these types of vessels are operating would see an expanded VTS service, more akin to air traffic control.¹⁰³ At the moment VTS is very much an advisory service, and even where the advice they give is followed and results in an accident, ultimate responsibility remains with the Master. The Finnpilot project is looking to expand both the power, and the knowledge required to run these types of service. At the moment VTS operators learn radio procedure, however they have a very basic understanding of the rules of the road and ship operations. It is likely that their role would have to become much more expansive in the future if MASS ships are to operate safely. An expanded VTS would be one example of the types of physical infrastructure that would be required for MASS vessels, including 5G connectivity for data sharing, so called "smart fairways" and better communications. This would presumably be the responsibility of the port to maintain, but certainly raises a question as to whether it would be even possible of such vessels to operate in multiple port ecosystems, and of course how they could operate in between such ecosystems.

Having said all this, remote pilotage is something that both shipowners and ports will be motivated to introduce. Ports will clearly pass on any costs of such a system to shipowners, however the amount of maintenance required would probably be much less than the current infrastructure. For example, in larger rivers such as the Elbe or the St Lawrence pilots are either required to spend time at staging posts, or travelling to and from vessels, reducing the amount of time they can be engaged on actual pilotage duties. Overall, the costs involved in running remote pilotage will be much less than with onboard pilots. Shipowners will obviously like this, as well as reducing waiting times at pilot stations. Indeed, this can already be shown by how keen shipowners are for their masters to have pilotage exemption certificates for ports they regularly visit. Quite apart from this, there is a safety element to this too. Embarking pilots can be very dangerous, and whilst shipowners will not spend excessive amounts to improve safety, they are often very keen to look to improve overall safety if it can provide other benefits.

¹⁰³ Wartsila, "Pilotage Digitalisation. How Remote is the Remote Pilotage" <https://www.wartsila.com/insights/article/pilotage-digitalisation-how-remote-is-the-remote-pilotage> (last tested on 1 November 2021)

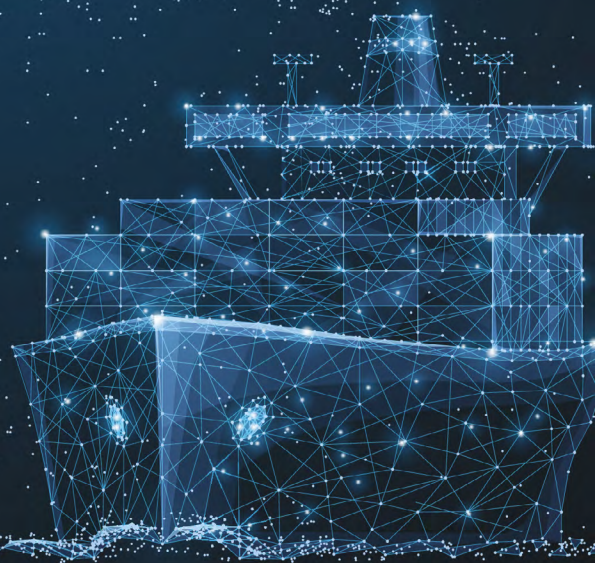
APPENDIX 2

Acronyms & Abbreviations

BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
Colregs	International Regulations for Preventing Collisions at Sea 1972 (as updated)
IMO	International Maritime Organisation
LLMC	Convention on Limitation of Liability for Maritime Claims 1976
MASRWG	Maritime Autonomous Systems Regulatory Working Group
MASS	Maritime Autonomous Surface Ship
MCA	Maritime and Coastguard Agency
MSA	Merchant Shipping Act 1995
MTOM	Maximum Take Off Mass
RCC	Remote control centre
SOLAS	International Convention for the Safety of Life at Sea 1974
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1984
UAS	Unmanned Aircraft Systems
UNCLOS	UN Convention on the Law of the Sea 1982
VLOS	Visual Line of Sight

CARGO

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